U.S. Department of Transportation
Research and Special Programs Administration
400 Seventh St., S.W.
Washington, D.C. 20590

NOV 29, 2002

Mr. Glynn Blanton
Chief, Gas Pipeline Safety Division
Tennessee Regulatory Authority
460 James Robertson Parkway
Nashville, TN 37243-0505

Dear Mr. Blanton:

On June 18, 2002, the Tennessee Regulatory Authority (TRA) notified the Office of Pipeline Safety (OPS) that it had approved, as amended, the application of the Nashville Gas Company (NGC), a Division of Piedmont Natural Gas Company, Inc., for a waiver from the requirements of Title 49 CFR §§ 192.121 and 192.123(a).

In a letter dated August 14, 2002, OPS objected to the waiver and under 49 U.S.0 60118(d), TRA's action granting the NGC waiver was stayed. In that letter, OPS indicated that it would reconsider the objection if TRA provided additional information.

In a letter dated September 5, 2002, TRA provided the requested additional information to OPS. Based on your letter and the technical information provided by NGC, the following is our understanding of the critical issues:

1. NGC will install defect free PA11 plastic pipe in accordance with written procedures submitted to TRA. The installation of PA11 plastic pipe will be in a class 3 location and consist of 3 miles of 1-inch IPS service tubing and 2 miles of 2-inch IPS main line. The installation is for a trial period not to exceed 30 months.

2. The maximum allowable operating pressure for this piping system will be limited to 175 psig for the duration of the waiver. OPS concurs with TRA's reasoning that the information provided from a 0.40 design factor will provide valuable operational and plastic pipe design information to both the regulatory and industry community alike.

3. The TRA Gas Pipeline Safety staff will be present during the installation of all service lines, hot taps, and removal of test coupons. Only SDR 11 mechanical tap tees will be used while performing hot taps on PA11 plastic pipe material.

4. NGC will remove sections of the PA11 plastic pipe for testing and evaluation at twelve (12) and twenty-four (24) month periods from the date of installation. Tests will be performed with the Gas Technology Institute to insure that the PA11 plastic pipe continues to be free from defects and meet the requirements of ASTM D2513-96a. If test results indicate that the PA11 plastic pipe material does not meet the requirements of ASTM D2513-96a and is unsafe, the pipeline shall be replaced, repaired, or removed from service.

5. Provided the test results of the pipe material show that the PA11 plastic pipe material has remained defect free, the PA11l plastic pipe may continue to operate with a MAOP of 175 psig for a period of not more than 6 months after the 24 month period. After such time, the MAOP of the PA11 plastic pipe material will be lowered to 100 psig.

The results of the tests with be filed with TRA and made available to OPS upon request.

Based on the above representations, we are withdrawing our objection and the waiver may take effect as

planned.

Sincerely,
Stacey L. Gerard
Associate Administrator
For Pipeline Safety

U.S. Department of Transportation
Research and Special Programs Administration
400 Seventh St., S.W.
Washington, D.C. 20590

AUG 14 2002

Mr. Glynn Blanton
Chief, Gas Pipeline Safety Division
Tennessee Regulatory Authority
460 James Robertson Parkway
Nashville, TN 37243-0505

Dear Mr. Blanton:

We have considered your letter of June 18, 2002, notifying us that the Tennessee Regulatory Authority (TRA) has approved the application of the Nashville Gas Company (NGC), a Division of Piedmont Natural Gas Company, Inc., for a waiver from 49 CFR §§ 192.121 and 192.123(a). The waiver would permit NGC to operate plastic pipe made of polyamide resin (also known as Nylon 11, PA 11, or Rilsan^{7m}) at operating pressures of up to 200 psig, or 100 psig above the current limit under § 192.123(a). The proposed 200 psig limit is based on using a design factor of 0.40, instead of the currently required 0.32, in the design formula in § 192.121.

To properly evaluate the safety of the pipeline system and of the 0.40 design factor, we need more information than your letter or the TRA order provides. Therefore, we object to the waiver, and under 49 U.S.C. § 60118(d), TRA's action granting the waiver is stayed.

We will reconsider our objection if you provide the following information regarding the proposed system:

1. Please indicate the diameters of the PA 11 plastic pipe to be used in the main and service lines.

2. Please indicate the SDR numbers of the PA 11 plastic pipe to be used in the main and service lines.

3. Please indicate the class location of the main and service lines.

4. Please indicate if the waiver is permanent or only for a trial period in conjunction with the Gas Technology Institute study. If the latter, please indicate the length of the trial period.

5. Please indicate if hot taps are to be performed on the PA 11 plastic pipe.

6. Please indicate if TRA staff will be present periodically during the installation of the PA 11 plastic pipe.

7. Please indicate why TRA believes it is safe to use a design factor of 0.40 instead of 0.32 to determine the design pressure of PA 11 plastic pipe.

Sincerely,
Stacey L. Gerard
Associate Administrator
For Pipeline Safety

TENNESSEE REGULATORY AUTHORITY
460 James Robertson Parkway
Nashville, Tennessee 37243-0505

September 5, 2002

Ms. Stacey Gerard, Associate Administrator
U.S. Department of Transportation
RSPA/Office of Pipeline Safety
400 Seventh Street, SW Room 7128
Washington, D.C. 20590

Re: Additional information with respect to Nashville Gas Company, a Division of Piedmont Natural Gas Company, Inc. Request for Waiver of 49 CFR 192.121 and 192.123(a) of Part 192 of U.S.C. Title 49. TRA Docket Number 01-01133.

Dear Ms. Gerard:

Pursuant to your letter dated August 15, 2002, please find attached a detailed explanation of the referenced matter. This information is for your reconsideration of the Tennessee Regulatory Authority (TRA) order to allow the use of PAU with a 0.40 design factor at a higher operating pressure.

The attached document provides answers to your objections regarding Nashville Gas Company's (NGC) application and technical merits for the use of PA11 at a higher operating pressure. We have included NGC's comments to your questions with our response. The State of Illinois granted a waiver for Nicor to use PA11 piping systems at 160 psig, which is above the current pressure regulations. The program has been a success. This installation, because of the supply pressure, will be limited to a maximum allowable operating pressure of 175 psig for the life of the material. It is our opinion that as additional installations are being planned and executed by other state agencies, (Utah Department of Commerce has recently published a notice of their intent to approve a waiver), the main motivation should be to evaluate the PAH piping system as they will be used by the companies in their normal distribution system. Each of the subsequent installations should "raise the bar" by removing restrictions in order to proactively ascertain any potential problems that may arise under actual field conditions.

As outlined in the original order, TRA Gas Pipeline Safety staff will monitor the installation and quality assurance procedures developed specifically for PA11 during the installation of the main, all service lines, hot taps and testing coupons removed at twelve (12) and twenty-four (24) month intervals. Several provisions have been incorporated as part of the original order to ensure the safety and reliability of the gas distribution system. Additional leakage surveys beyond the requirements of Section 192.723 of the Minimum Federal Safety Standards will be performed and line markers identifying the area of the proposed project will be installed.

I would appreciate your prompt response in order to allow NGC to install the material before the heating season. If your organization has any additional questions or comments pertaining to the enclosed information please let us know.

Sincerely,
Glynn Blanton, Chief
Gas Pipeline Safety Division

Tennessee Regulatory Authority Response to Questions from US DOT/RSPA

1. *Please indicate the diameters of the PA11 plastic pipe to be used in the main and service lines*. **Answer**: The proposed installation will be installed in Nashville Gas Company (NGC) service territory located in Mount Juliet, Wilson County, Tennessee along Rutland Road and Hunting Hills Road. The proposed project consists of 2-inch IPS main and 1-inch IPS service tubing as mentioned in TRA order/NGC's application. An additional copy of the TRA order and NGC application and map is attached.

2. *Please indicate the SDR numbers of the PA11 plastic pipe to be used in the main and service lines*. **Answer**: The 2-inch IPS main and 1-inch IPS service tubing is SDR 11. Mechanical tap tee is SDR11.

3. *Please indicate the class location of the main and service lines*. **Answer**: The main and service lines will be installed in a class 3 location.

4. *Please indicate if the waiver is permanent or only for a trial period in conjunction with the Gas Technology Institute study. If the latter, please indicate the length of the trial period*. **Answer**: The waiver is only for a trial period. The TRA order is site specific and consists of the location mentioned in item one above. The order includes provisions for removal of test sections of pipe at 12 and 24 month intervals to review in-service conditions. After removing pipe sections at the end of 24 months and performing necessary tests with Gas Technology Institute (GTI) and insuring results indicate that the pipe is free from defects and meets ASTM D 2513-96a requirements, the installation will be allowed to remain in service at 175 psig until the 24 month test data has been reviewed by GTI but not to exceed 6 months. After test data has been reviewed but not later than 6 months after the 24 month period the pressure will be lowered to 100 psig. If test results indicate the material does not meet ASTM D2513-96a requirements the pressure will be lowered to 100 psig or project abandoned in place.

5. *Please indicate if hot taps are to be performed on the PA11 plastic pipe*. **Answer**: It is the intention of the TRA to allow hot taps on PA11 piping systems using only mechanical tap tees. TRA, NGC, and manufacturer representatives from each of the materials used in the hot tap will be present to review the taps for quality control. The initial installation within the Nicor Gas service territory (Illinois Waiver ICC Docket No.: 98-0494) allowed the use of PA11 at higher operating pressure (160 psig) but did not allow hot tapping for additional service lines. Comprehensive testing carried out by the Gas Technology Institute corroborates the PA11 material's ability to perform hot tapping at pressures up to 200 psig. As a result, the intention of this order is to allow the use of hot tapping to provide gas service to additional customers after the initial installation has taken place. Furthermore, we believe that the idea of the proposed installation is to test and evaluate the performance characteristics of PA11 piping systems under field conditions in order to proactively identify any potential problems.

6. *Please indicate if TRA staff will be present periodically during the installation of the PAR plastic pipe*. **Answer**: In accordance with our letter dated June 18, 2002, the "TRA Gas Pipeline Safety staff will monitor the installation and quality assurance procedures developed specifically for PA11". We will be present on the installation of the entire project and during the installation of all service lines, hot taps, and removal of test coupons at the twelve and twenty- four month period. All records regarding the use of the pipe as it applies to material, length, pressure test, pipe size, wall thickness, environmental conditions, and class location will be reviewed by our staff. On June 21, 2002 TRA gas safety engineers reviewed all qualifying procedures related to joining of the material and participated in qualifying NGC's joiners for PA1 1.

7. *Please indicate why IRA believes it is safe to use a design factor of 0.40 instead of 0.32 to determine the design pressure of PA11 plastic pipe*. **Answer**: While our agency would not currently endorse amendment of Section 192.121 to reflect a design factor of 0.40, we feel that this pilot project would provide valuable data to the regulatory and industry community for consideration of such an amendment in the future. The reasons for allowing the use of a 0.40 design factor are as follows:

    - Improved materials and quality control. Resins utilized in the production of plastic pipe today perform

better under stress compared to materials of the 60's and 70's. Manufacturing processes have improved through the years so that plastic pipe is produced with much closer tolerances than "vintage" pipe of 30 years ago.

- Accepted under other standards. The Canadian Standards Association (CSA) has recently adopted a design factor of 0.40. The International Standards Organization (ISO) assigns design stresses of 580 psig and 725 psig to medium density (MDPE) and high density (HDPE). These values are equivalent to design factors of 0.48 and 0.45 for MDPE and HDPE respectively. A design factor of 0.50 has been an accepted practice in the United States for design of thermoplastic pipe in water applications.

- Design factor basis. The original Section 192.121 of the Minimum Federal Safety Standards included design factors based on class location. Design factors of 0.32 for class 1, 0.25 for class 2 & 3, and 0.20 for class 4 were the accepted standards. In 1978, amendment 192-31 combined these factors into a single standard for all class locations (0.32). At that time, several comments were made to the proposed rule change in support of a common 0.40 design factor based on many years of satisfactory use prior to the adoption of Section 192.121.

- Continuing studies. PA11 gas piping material has been studied extensively under laboratory and field conditions to characterize its integrity under various failure modes. Gas Technology Institute in conjunction with Nicor has compiled data pertaining to short-term ductile and long-term slow crack growth failures in PA11 piping material. Nicor established two pilot projects with operating pressure of 150 psig or more and has proven PA11 material's ability to withstand higher operating pressures.

Nashville Gas Company
885 MAINSTREAM DRIVE
NASHVILLE, TENNESSEE 37228

September 3, 2002

Glynn Blanton
Chief, Gas Pipeline Safety Division
Tennessee Regulatory Authority
460 James Robertson Parkway
Nashville, TN 37243-0505

SUBJECT: PA11 High Pressure Pipe

Nashville Gas Company has received a copy of the letter from Stacey L. Gerard with U. S. Department of Transportation on August 14, 2002 requesting additional information regarding our waiver petition. In response to the questions listed in that letter, we offer the following information to help you in formulating your reply.

1. *Please indicate the diameters of the PA11 plastic pipe to be used in the main and service lines.*

   - **Answer**: The proposed installation within the Nashville Gas service territory along Rutland Road and Hunting Hills Road in Wilson County consists of 2-inch IPS main size and 1-inch IPS service tubing.

2. *Please indicate the SDR numbers of the PA 11 plastic pipe to be used in the main and service lines*.

   - **Answer**: The 2-inch IPS main and 1-inch IPS service tubing is SDR 11. Mechanical tap tee is SDR11.

3. *Please indicate the class location of the main and service lines*.

   - **Answer**: The main and service lines will be installed in a class 3 location.

4. *Please indicate if the waiver is permanent or only for a trial period in conjunction with the Gas Technology Institute study. If the latter, please indicate the length of the trial period*.

   - **Answer**: The TRA order is site specific and consists of the location mentioned in item one above. The order includes provisions for removal of test sections of pipe at 12 and 24 month intervals to review in-service conditions. After removing pipe sections at the end of 24 months and performing necessary tests with Gas Technology Institute and insuring results indicate that the pipe is free from defects and meets ASTM D 2513-96a requirements, the installation will be allowed to remain in service at the current operating pressure (175 psig) until the test results are known. The entire test period is not to exceed 30 months. <u>If test results indicate the material does not meet these requirements the pressure will be lowered or project abandoned in place.</u>

5. *Please indicate if hot taps are to be performed on the PA 11 plastic pipe*.

   - **Answer**: It is the intention of the TRA to allow hot taps on PA11 piping systems using only mechanical tap tees. TRA, NGC, and manufacturer representatives from each of the materials used in the hot tap will be present to review the taps for quality control. The initial installation within the Nicor Gas service territory (Illinois Waiver ICC Docket No.: 98-0494) allowed the use of PA11 at higher operating pressure (160 psig) but did not allow hot tapping for additional service lines. Comprehensive testing carried out by the Gas Technology Institute corroborates the PA11 material's ability to perform hot tapping at pressures up to 200 psig. As a result, the intention of this order is to allow the use of hot tapping to provide gas service to additional customers after the initial installation has taken place. Furthermore, we believe that the idea of the proposed installation is to test and evaluate the performance characteristics

of PA11 piping systems under field conditions in order to proactively identify any potential problems.

6. *Please indicate if TRA staff will be present periodically during the installation of the PA 11 plastic pipe.*

   - **Answer**: In accordance with our letter dated June 18, 2002, the "TRA Gas Pipeline Safety staff will monitor the installation and quality assurance procedures developed specifically for PA11". We will be present on the installation of the entire project and during the installation of all service lines, hot taps, and removal of test coupons at the twelve and twenty-four month period. All records regarding the use of the pipe as it applies to material, length, pressure test, pipe size, wall thickness, environmental conditions, and class location will be reviewed by our staff. On June 21, 2002 TRA gas safety engineers reviewed all qualifying procedures related to joining of the material and participated in qualifying NGC's joiners for PA11.

7. *Please indicate why TRA believes it is safe to use a design factor of 0.40 instead of 0.32 to determine the design pressure of PA11 plastic pipe.*

   - **Answer**: We concur with the attached information provided by Hitesh Patadia representing Gas Technology Institute.

We hope this information is helpful to you in preparation of your response. Please call me if you need additional information.

Sincerely,
John L. Clark, Jr.

Attachments:
1) Answer to Question 7 as provided by Hitesh Patadia
2) Technical Reference Summary (3 copies)
3) PA11 Project Drawing (3 copies)

Attachment: Response to Question 7 from Hitesh Patadia representing Gas Technology Institute

7. Based on a review of all the comprehensive laboratory testing data and field performance history of the PAll piping system, the TRA has allowed the use of a 0.40 design factor for this particular installation only. The reasons for allowing the use of a 0.40 design factor are as follows:

   - As previously mentioned, as additional installations are being planned and executed, the main motivation should be to evaluate the PA11 piping systems as they will be used on a commercial basis. Given that the safe operating performance at higher operating pressures has already been demonstrated, each of the subsequent installations should increase the "bar" by removing restrictions in order to proactively ascertain any potential problems that may arise under actual field conditions.

   - To ensure the safety and integrity of the system, the TRA has imposed several additional requirements. Namely, the entire line will be subjected to a pressure test at 200% of the maximum allowable operating pressure (i.e. 350 psig), which is in excess of the requirements of Subsection 192.513. Nashville Gas must maintain line markers and appropriate signage in the area of the proposed pipeline and conduct leak surveys twice the first year and than annually for five years, which is also beyond the requirements of 192.723. Finally, Nashville Gas must remove a cross-section of the installed line at both twelve (12) and twenty-four (24) month time period for testing and evaluation purpose to ensure the pipe meets ASTM D 2513-96a requirements.

   - The use of PA11 piping systems at the proposed operating pressure and a 0.40 design factor does not adversely affect pipeline safety. Rather, the factor of safety for Pa11 piping systems is still greater than other plastic piping systems, as illustrated in the example below.

     PA11 piping materials have an established Plastics Pipe Institute (PPI) HDB ratings of 2500 psi at design temperatures of 73°F, 1600 psig at design temperatures of 140°F, and 1250 psi at design temperatures of 182°F. At typical design temperatures of 73°F, the design pressure per 192.121 (with the requested change) for a 2-inch IPS SDR11 system with a design factor of 0.40 is calculated to be 200 psig, as shown below.

$$P = 2S\frac{t}{(D-t)}x0.40 \qquad \text{(i)}$$

or alternatively,

$$P = \frac{2S}{(SDR-1)}x0.40 \qquad \text{(ii)}$$

Where:

p =	design pressure, gage, psi
S =	long term hydrostatic strength, as stated by the material HDB rating at the design temperature, psi
SDR =	Standard Dimension Ratio defined as the ratio of the nominal outside diameter to the wall thickness
0.40 =	REVISED design factor

$$P = \frac{2(2500\,psi)}{(11-1)}x0.40$$

$$P = 500x0.40$$

$$P = 200\,psig$$

Letting PL represent the *ultimate hoop strength* of a plastic material as calculated by its dimensions and long-term strength (based on a design life of 50 years), as shown in Equation 1:

$$P_L = \frac{2S}{(SDR-1)} \qquad (1)$$

Where:

PL = Ultimate hoop strength, psi

S = For thermoplastic pipe the long-term hydrostatic strength determined in accordance with the listed specification at a temperature equal to 23°C (73°F), 38°C (100°F), 49°C (120°F), or 60°C (140°F); for reinforced thermosetting plastic pipe, 75,800 kPa (11,000 psi).

SDR = Standard Dimension Ratio defined as the ratio of the outside diameter to the wall thickness

Then, for SDR11 PE systems with a long-term hydrostatic strength of 1250 psi, the ultimate hoop strength (PL) is:

$$P_L = \frac{2(1250)}{(11-1)} \qquad (2)$$
$$P_L = 250\,psi$$

The design pressure formulation, as stated in Part 192.121, is simply the product of the ultimate hoop strength, PL, times the design factor or factor of safety, 0.32.

$$P = P_L * 0.32$$
$$P = 250 * 0.32 \qquad (3)$$
$$P = 80\,psig$$

For the sake of conservatism, the design factor for PE systems is left unchanged, F = 0.32, in order to illustrate the inherent factor of safety for PA11 piping systems due to its increased long term strength as stated by the HDB rating. From Equations (2) and (3), the resulting pressure differential or factor of safety, Δ_{FS} for PE systems, is simply the difference between the ultimate hoop strength and the design pressure is 170 psig:

$$\Delta_{FS} = P_L - P$$
$$\Delta_{FS} = 250 - 80 \qquad (4)$$
$$\Delta_{FS} = 170\,psig$$

Likewise, using Equation 1 for SDR11 PA11 piping systems with a long-term strength of 2500 psi, the ultimate hoop strength (PL) is:

$$P_L = \frac{2(2500)}{(11-1)} \qquad (5)$$
$$P_L = 500\,psi$$

From Equation 3, the design pressure for P11 is then (assuming also a design factor of 0.32):

$$P = P_L - 0.32$$
$$P = 500 - 0.32 \qquad (6)$$
$$P = 160\,psig$$

The resulting pressure differential or factor of safety, Δ_{FS}, between the ultimate hoop strength and the design pressure is 340 psig or 200% more than the what is allowed for PE materials — See Equation (4):

$$\Delta_{FS} = P_L - P$$
$$\Delta_{FS} = 500 - 160 \qquad (7)$$
$$\Delta_{FS} = 340\,psig$$

In a similar fashion using Equation 3, with a design factor of 0.40 for PA11, the design pressure and the resulting pressure differential are then:

$$P = P_L - 0.40$$
$$P = 500 - 0.40 \qquad (8)$$
$$P = 200\,psig$$

$$\Delta_{FS} = P_L - P$$
$$\Delta_{FS} = 500 - 200 \qquad (9)$$
$$\Delta_{FS} = 300\,psig$$

The results of the preceding analysis are summarized in Table 1 below:

Item	MDPE (F = 032)	MDPE (F=0.40)	PA11 (F=0.32)	PA11 (F=0.40)
Size	2-inch SDRI 1	2-inch SDR11	2-inch SDR11	2-inch SDR11
HDB Rating at 73°F	1250 psi	1250 psi	2500 psi	2500 psi
Ultimate Hoop Strength (P_L), psi	250 psi	250 psi	500 psi	500 psi
Design Pressure, psig	80 psig	100 psig	160 psig	200 psig
Pressure Differential (Factor of Safety)	170 psig	150 psig	340 psig	300 psig

Table 1: Theoretical factor of safety for PE and PAH piping systems

Comparing the resulting pressure differential for PE systems to PA11 systems using a design factor of 0.32, the margin of safety imposed on the Pal11 is approximately 2 times greater for PA11 systems as compared to PE (340 psig versus 170 psig). By increasing the design factor, F = 0.40, the resulting pressure differential is still approximately 2 times the margin of safety associated with PE systems. Furthermore, if one considers the magnitude of the pressure differential for PE versus PA11, then it is clear that an increase in the design factor still provides Nashville Gas with a greater margin of safety for PA11 systems as compared to PE.

TENNESSEE REGULATORY AUTHORITY
460 James Robertson Parkway
Nashville, Tennessee 37243-

June 18, 2002

Ms. Stacey Gerard, Associate Administrator
US Department of Transportation
RSPA/Office of Pipeline Safety
400 7th Street, SW Room 7128
Washington, DC 20590

RE: Nashville Gas Company, a Division of Piedmont Natural Gas Company, Inc. Request for Waiver of 49 CFR 192.121 and 192.123 (a) of Part 192 of U.S.C. Title 49. TRA Docket Number 01-0113.

Dear Ms. Gerard:

Please find enclosed the order of the Tennessee Regulatory Authority (TRA) in the referenced matter. We are submitting the order and Nashville Gas Company (NGC) petition for review and action in accordance with 49 USC 60118(a). NGC requests action on this matter to allow installation of the proposed PA 11 material along Rutland Road and Hunting Hills Road in Wilson County, Mt. Juliet, Tennessee within their service territory.

TRA Gas Pipeline Safety staff will monitor the installation and quality assurance procedures developed specifically for PA 11. We will review all records regarding the use of the pipe as it applies to material, length, pressure test, pipe size, wall thickness, environmental conditions, class location, and qualifying procedures for joining of the material. We will require NGC to remove a cross-section of the PA 11 pipe for testing and evaluation of the material's aging characteristics at both the twelve (12) and twenty-four (24) month periods from the date of installation. The results of these tests will be filed with our agency and made available to the Office of Pipeline Safety upon request. The proposed pressure test of the PA 11 will be at 200 percent of the maximum allowable operating pressure, which is in excess of the requirement of Subsection 192.513. NGC shall maintain line markers and appropriate signage in the area of the proposed pipeline and conduct leak surveys twice in the first year and then annually for five years, which is beyond the requirement of 192.723.

If the TRA does not receive a response from the Federal Office of Pipeline Safety within sixty days of receipt of the order, we understand that NGC will be free to proceed under the provisions of the order. If you have any questions regarding this matter, please contact Richard Collier, General Counsel, at 1-800-342-8359 extension 170 or me at extension 185. Your prompt response to this request is appreciated.

Sincerely,
Glynn Blanton Chief
Gas Pipeline Safety Division

BEFORE THE TENNESSEE REGULATORY AUTHORITY
NASHVILLE, TENNESSEE
June 17, 2002

IN RE:		**)**
		)
APPLICATION OF NASHVILLE GAS COMPANY, A	**)**	**DOCKET NO.**
DIVISION OF PIEDMONT NATURAL GAS COMPANY,	**)**	**01-01133**
INC. FOR A WAIVER OF SECTIONS 192.121 AND	**)**	
192.123(A) OF PART 192 OF U.S.C. TITLE 49		**)**

ORDER APPROVING WAIVER OF THE REQUIREMENTS REGARDING PIPE DESIGN PURSUANT TO 49 C.F.R. ft§ 192.121 AND 192.123(a)

This matter came before the Tennessee Regulatory Authority ("Authority") at a public hearing held on May 7, 2002, for consideration of an application filed by Nashville Gas Company ("NGC") for a waiver of 49 C.F.R. §§ 192.121 and 192.123(a) regarding the design of plastic pipe utilized in its gas distribution system.

BACKGROUND

On December 19, 2001, NGC filed its *Application of Nashville Gas Company, a Division of Piedmont Natural Gas Company, Inc. for a waiver of Sections 192.121 and 192.123(a) of Part 192 of U.S.C. Title 49 to permit the use of polyamide resin (also known as Nylon 11, PA 11, or Rilsan™) as a piping material to distribute natural gas at operating pressures up to 200 psig as limited by its approved Plastic Pipe Hydrostatic Design Basis design factor of 0.40 and the use of the design formula contained within Section 192.121* ("Application"). Upon acknowledging that the Application contained ambiguities and that the supporting information provided therein was incomplete, NGC filed an amended Application bearing the same title on March 5, 2002.[1]

The amended Application requests a waiver from the Minimum Federal Safety Standards ("MFSS") regarding the design of plastic pipe found at 49 C.F.R. §§ 192.121 and 192.123(a). These standards have been adopted by the Tennessee Regulatory Authority.[2] Section 192.121 sets forth formulas for determining the design pressure for plastic pipe.[3] Section 192.123(a) sets forth limitations regarding design pressure and operating temperatures.[4] NGC seeks Authority approval for use of polyamide resin (also known as Nylon 11, PA 11, or Rilsan™) as a piping material to be used in the distribution of natural gas. NGC proposes to utilize this piping material at operating pressures which may vary from the requirements of Section 192.123 by up to 200 psig as limited by its Plastic Pipe Institute Hydrostatic Design Basis rating[5] of 2500 psi, and using a design factor of 0.40 in the formula contained within 49 C.F.R. § 192.121.

This piping material will be used at a site located in Mount Juliet, Wilson County, Tennessee along Rutland and Hunting Hills Roads. There will be two miles of main line and three miles of service line that will potentially serve thirty to forty customers in the service area. NGC will maintain records regarding the use of the polyamide resin material including the type of material, location, length, pressure, pipe size, wall thickness, environmental conditions and class location.

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[1] The amended Application provided additional information to the Authority including the results of a study performed by Nicor Technologies for the Gas Research Institute. In support of the amended Application, NGC provided information showing that PAU has been approved under American Society for Testing and Materials (ASTM) D2513-96a with a HDB rating of 2500 psi. NGC relies on third party testing and evaluations of the PA11 material by the Gas Technology Institute that corroborates the material's strength, integrity, and performance. NGC points out the continued safe operability of two separate installations of PA 11 piping systems operating over 150 psig,. One of these systems is operating at 160 psig in the Nicor Gas distribution netwotik under a waiver approved by the Illinois Commerce Commission (ICC Docket No: 9S0494)_

[2] Tenn. Code Ann. § 65-28-104 (Supp. 2001).

[3] 49 C.F.R. § 192.121 (2002).

[4] 49 C.F.R. § 192.123 (2002).

[5] The PA11 Hydrostatic Design Basis (HDB) rating was established after tests conducted under the auspices of the Plastic Pipe Institute (PPI) and the ASTM. The Gas Technology Institute (formerly Gas Research Institute) has conducted thirty tests and evaluations corroborating the material's strength, integrity and performance.

After twelve (12) months, and again after twenty-four (24) months, NM will remove certain cross-sections of pipe for testing and evaluation of the aging characteristics of the material.

Among the safety measures being taken, NGC will pressure test the newly installed pipe at 350 psig (200% of the maximum operating pressure of 175 psig) and maintain appropriate signage and line markers. NGC will also conduct a leak survey of the installed pipe, twice the first year, and on an annual basis thereafter for 5 years. NGC will otherwise conform to all other related requirements of Sections 192.191, .281 and .287. These tests and evaluations will be performed by the Gas Technology Institute and the results will be provided to the Authority and the federal government's Office of Pipeline Safety.

FINDINGS AND. CONCLUSIONS

In considering a request for a waiver of the requirements set forth in 49 C.F.R. §§ 192.121 and 192.123(a), the Authority must comply with the same requirements for granting a waiver as those placed on the United States Secretary of Transportation in 49 U.S.C. § 60118.[6] Under these requirements, the Authority may waive compliance with any part of an applicable standard on terms it considers appropriate if the waiver is not inconsistent with pipeline safety.[7]

At the public hearing conducted on May 7, 2002, the Directors unanimously approved the request for waiver based on the following findings:

1. NGC is a gas public utility as defined in Tenn. Code Ann. § 65-28-104, and as such, is subject to the jurisdiction of the Authority pursuant to Tenn. Code Ann. § 65- 28-106.

2. Through its request for a waiver of the Minimum Federal Safety Standards set forth at 49 C.F.R. §§ 192.121 and 192.123(a), NGC is asking that it be allowed to use polyamide resin (also known as Nylon 11, PA 11, or Rilsanni) as a piping material to distribute natural gas at operating pressures up to 200 psig as limited by its Plastic Pipe Institute Hydrostatic Design Basis rating of 2500 psi, and using a design factor of 0.40 in the formula contained within 49 C.F.R. § 192.121.

3. The Authority concludes that the waiver of the requirements set forth in 49 C.F.R. §§ 192.121 and 192.123(a) is a practical solution for gas distribution that is not inconsistent with pipeline safety or the integrity of the pipeline.

IT IS THEREFORE ORDERED THAT:

1. The *Application of Nashville Gas Company, a Division of Piedmont Natural Gas Company, Inc. for a waiver of Sections 192.121 and 192.123(a) of Part 192 of U.S.C. Title 49 to permit the use of polyamide resin (also known as Nylon 11, PA II, or Rilsan as a piping material to distribute natural gas at operating pressures up to 200 psig as limited by its approved Plastic Pipe Hydrostatic Design Basis design factor of 0.40 and the use of the design formula contained within Section 192.121*, as amended, is approved and the waiver requested therein is granted.

2. A written notice of the waiver granted herein shall be transmitted to the Office of the Secretary of Transportation consistent with the requirements set forth at 49 U.S.C. 60118(d).

3. This Order will be effective sixty (60) days from the date the Secretary of Transportation receives the written notice of the waiver unless an objection is entered by the Secretary in accordance with the requirements of 49 U.S.C. 60118(d).

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[6] 49 U.S.C. § 60118 (2001) provides in pertinent part that a "State authority may waive compliance with a safety standard in the same way and to the same extent the Secretary may waive compliance under subsection (c) of this section." Subsection (c) of 49 U.S.C. § 60118 provides that "the Secretary by order may waive compliance with any part of an applicable standard . . . after notice and an opportunity for a

[7] Subsections (c) and (d) of 49 U.S.C. § 60118 have been interpreted through the United States Department of Transportation's Guidelines for States Participating in the Pipeline Safety Program (May 1996). Chapter 3 of this publication provides specific guidelines for state agencies in considering a waiver of federal regulation involving intrastate pipelines. The guidelines mirror the requirements set forth at 49 U.S.C. § 60118 (2001) and provide some additional specifics regarding the interaction between the state agency and the office of the Secretary of Transportation.

Sara Kyle, Chairman

H. Lynn Greer, Jr., Director

Melvin J. Malone, Director

K. David Waddell, Executive Secretary

Piedmont Natural Gas Company
Post Office Box 33068
Charlotte, North Carolina 21303'

March 4, 2002

Mr. David Waddell
Executive Secretary
Tennessee Regulatory Authority
460 James Robertson Parkway
Nashville, Tennessee 37243-0505

Docket No. 01-01133

Dear Mr. Waddell:

Enclosed for filing are 14 copies of a revised petition for Nashville Gas, a division of Piedmont Natural Gas, in the above captioned docket. The original petition, filed on December 19, 2001, requested a waiver of certain statutes to permit the use of new technologies in plastic piping within the Company's service territory. The revised petition incorporates certain recommendations made by the Authority Staff that were discussed with the Company subsequent to the original filing.

I am enclosing an additional copy of the Petition that I would appreciate your stamping "filed" and returning in the enclosed envelope.

As always, if you, the Directors or the Staff have questions about the enclosed information, please do not hesitate to contact me.

Sincerely,
Bill R. Morris
Director-Rates

Before The
Tennessee Regulatory Authority

Nashville, Tennessee

In the Matter of :	)
Application of Nashville Gas Company, a	)
Division of Piedmont Natural Gas	)
Company, Inc. for a waiver of Sections	)Revised Petition
192.121 and 192.123(a) of Part 192 of	
U.S.C. Title 49 to permit the use of	)
polyamide resin (also known as Nylon 11,	)
PA 11, or RilsanTM) as a piping material to	
distribute natural gas at operating pressures	
up to 200 psig as limited by its approved	
Plastic Pipe Hydrostatic Design Basis design	
factor of 0.40 and the use of the design	
formula contained within Section 192.121.	
	)

Docket No. 01-01133

1. Piedmont is incorporated under the laws of the State of North Carolina and is engaged in the business of transporting, distributing and selling gas in the States of Tennessee, North Carolina and South Carolina. Piedmont's principal office and place of business is located at 1915 Rexford Road, Charlotte, North Carolina.

2. Piedmont conducts its natural gas distribution business in the State of Tennessee through its operating division, Nashville Gas. Nashville Gas' natural gas distribution business is subject to regulation and supervision by the Commission pursuant to Chapter 4 of Title 65 of the Tennessee Code Annotated.

3. Nashville Gas has its principal offices at 665 Mainstream Drive, Nashville, Tennessee, and it is engaged in the business of furnishing natural gas to customers located in Davidson County and portions of the adjoining counties of Cheatham, Dickson, Robertson, Rutherford, Sumner, Trousdale, Williamson and Wilson and in certain incorporated towns and cities located therein.

4. It is respectfully requested that any notice or other communications with respect to this Petition be sent to:

John L. Clark Jr.
Vice President — Tennessee Operations Nashville Gas Company
665 Mainstream Dr
Nashville, TN 37228

5. Nashville Gas operates and maintains over 2659 miles of distribution mains, which operate between 0.25 to 450 psig using pipe diameters between 1 to 14 inches. These mains meet the requirements in Part 192 of U.S.C. Title 49. In this application, Nashville Gas proposes, subject to the approval of the proposed test site by the Authority, the installation of up to two (2) miles of main and three (3) miles of service line of PA11 piping. This project potentially will serve 30 — 40 customers within Petitioner's service territory, as identified on attached drawing, more specifically

along Rutland Road and Hunting Hills Road.

6. Nashville Gas requests the Authority to grant a waiver from both sections 192.121 and 192.123(a) to allow the use of SDR 11 Polyamidel1 (PA11) piping systems within it's distribution system in order to provide gas service in a more cost efficient manner. More specifically, Nashville Gas requests the Authority to grant a waiver of subparts192.121 and 192.123(a) to allow a maximum design pressure greater than 100 psig. Specifically, Petitioner requests a maximum design pressure up to 200 psig for the proposed PA11 SDR11 piping system as limited by its PPI HDB rating of 2500 psi and using a design factor of 0.40 in the formula contained within §192.121. The following discourse sets forth the reasons why subparts192.121 and 192.123(a) should be waived by the Authority and approved by the Office of Pipeline Safety (OPS), and what measures Petitioner shall use to ensure that gas pipeline safety will not be compromised

7. Petitioner proposes that the design factor of 0.32 in the formula in subsection 192.121 be increased to 0.40. The design factor is used to account for nominal variations in material and manufacturing quality, as well as to compensate for other stresses in the pipe that are unrelated to internal pressure, such as earth loading, subsidence, compression fittings, and temperature changes. The design factor of 0.32 was adopted from the United States of America Standards (USAS) code (now American Society of Mechanical Engineers Code B31.8). The design factor in B31.8 and Part 192.121 were initially published over 25 years ago and have been unchanged since that time. Currently manufactured plastic pipes, particularly PA11 pipes, which have been approved by the American Society for Testing and Materials (ASTM), are manufactured with very little variation in material and manufacturing quality. In addition, stresses in pipes, other than internal pressures, have been found to have a more limited effect than previously thought. A final draft of the petition to increase the design factor to 0.40 has been conditionally approved by the OPS. Final comments are being addressed by the American Gas Association Plastic Materials Committee (AGA-PMC) that support the increase in the design factor for polyethylene gas piping materials, which have a HDB rating that is 50% less than the P11 material. This proposed revision clearly shows the basis for the increase of the 0.32 design factor and a justification for the change.

8. Petitioner proposes that the upper pressure limits in subsection 192.123(a) be raised to 200 psig for SDR1 I PA11 piping systems. PA11 has been approved under ASTM D2513-96a with a Hydrostatic Design Basis (HDB) rating of 2500 psi. The HDB rating for PA11 was established after long and exhaustive tests conducted under the auspices of the Plastic Pipe Institute (PPI) and the American Society for Testing and Materials (ASTM). Additionally, third party testing and evaluations of the PA11 material by the Gas Technology Institute (formerly Gas Research Institute) corroborates the material's strength, integrity, and performance. Most importantly however, is the continued safe operability of two separate installations of PA11 piping systems operating over 150 psig, as outlined in the attached Technical Reference Summary. These installations include one installation that is operating at 160 psig in the public right-of-way within the Nicor Gas distribution network under an approved waiver from the Illinois Commerce Commission (ICC Docket No: 98-0494). The public right-of-way installation has been in service for over one year and has validated the ability of PA11 piping systems to operate safely at pressures greater than 150 psig as limited by its long term performance properties. The second installation on private property has been in service for over three years at an operating pressure of 150 psig and has not experienced any problems. Characterization of the short-term and long-term mechanical properties have shown no deleterious effects of exposure to in-service conditions after approximately three years and six months of being under pressure at 150 psig.

9. The basis for both these waivers has been studied for several years and adequate tests have been conducted to verify that these waivers are justified. The supporting documents and the supplemental information with their respective attachments show the adequacy of these alternative standards. The alternative standards will not compromise pipeline safety. These waivers will assure that the regulations are kept current with advancing pipeline technology in conformance with the continuing goals of the Regulatory Reinvention Initiative conducted by the OPS in 1995-1997.

10. Petitioner proposes to use PA11in accordance with Petitioner approved installation and quality assurance procedures developed specifically for PA11. The following records will be maintained regarding the use of

these pipes: type of material, location, length, pressure, pipe size, wall thickness, environmental conditions, and class location. At the end of both a 12-month and 24-month time periods, Petitioner will remove certain cross-sections of pipe for testing and evaluation of the aging characteristics of the PA 1 1 pipe material. The testing and evaluation will be performed by the Gas Technology Institute. Petitioner will provide the results of the testing and evaluation to the Authority and OPS and assist the Authority and OPS in revising these regulations in accordance with the information gained from the use of PA11 pipe.

11. In order to assure adequate safety of the application of these waivers, Petitioner proposes to pressure test the newly installed pipe at 350 psig, which is 200 percent of the maximum operating pressure of 175 psig, which is in excess of the requirements set forth in subsection 192.513. Also, Petitioner shall conform to all other related requirements stated in subsections 192.191, 192.281, 192.285, and 192.287. Petitioner shall also maintain appropriate signage and line markers per approved Petitioner's procedures. In addition, Petitioner proposes to conduct a leak survey of the installed PA11 pipe twice the first year and then on an annual basis, for five years, which are beyond the requirements in subpart 192.723. At that time, normal survey intervals will begin, based on subsection 192.723, subject to the approval of the Authority.

Wherefore, based upon the foregoing, Petitioner respectfully requests the Authority to promptly grant a waiver of Sections 192.121 and 192.123(a) of Part 192 of U.S.C. Title 49 to permit the use of polyamide resin (also known as Nylon 11, PA 11, or Rilsan™) as a piping material to distribute natural gas at operating pressures up to 200 psig as limited by its approved Plastic Pipe Hydrostatic Design Basis design factor of 0.40 and the use of the design formula contained within Section 192.121.

Respectfully submitted this the 25th day of February 2002.

NASHVILLE GAS COMPANY, a division of PIEDMONT NATURAL GAS COMPANY

Nashville Gas Company, a division
of Piedmont Natural Gas Company
665 Mainstream Drive
Nashville, Tennessee 37228

Technical Reference Summary

"Safe and Reliable Use of PA1 1 Gas Distribution Systems Operating at Higher Pressures (160 — 200 psig)"

Executive Summary

The gas industry has long understood the advantages of plastic pipe. In addition to being easier to handle and join, the use of plastic pipe eliminates the need for long term corrosion control and its associated costs. Currently, the Code of Federal Regulations (49CFR Part 192) prohibits Local Distribution Companies (LDC) from using plastic pipe over 100 psig, consequently preventing its use in applications that would require intermediate pressure ranges (i.e. 100 — 300 psig). Petitions to the DOT Office of Pipeline Safety to remove the 100 psig limitation and to increase the design factor to 0.40 are pending final approvals. However, once approved, current MDPE and HDPE materials will still not be suitable to operate at substantially higher pressures than are currently being used. In order to be fully cost competitive with steel at these higher pressures, there is an increasing need for new plastic materials within the gas industry. However, before LDC's can deem any new plastic material acceptable for use, it must be subjected to a comprehensive range of testing and evaluation to firmly establish that it can be safely and economically utilized by the natural gas industry.

Consequently, a comprehensive research program was sponsored by the Gas Technology Institute (GTI, formerly Gas Research Institute), leading utilities, and gas industry manufacturers to evaluate the use of Polyamide 11 (PA11) piping systems at higher operating pressures. In applications experience abroad, it has been demonstrated that PA11 offers most of the common benefits of plastic pipe, while greatly extending the range of operating pressures due to its increased Hydrostatic Design Basis (HDB) rating. In particular, PA11 currently has a Plastic Pipe Institute (PPD HDB listing of 2500 psi at 23°C. As a result, SDR 11 P11 piping systems can operate at pressures two times greater than polyethylene (PE) pipe of equal size.

To demonstrate and validate its use, a hybrid approach consisting of comprehensive laboratory testing and actual field applications testing was utilized. The results of the testing and evaluation were consistent with expectations. In particular, the measured mechanical and physical properties were consistent with established ASTM D2513 specifications. A pilot installation operating at 150 psig confirmed that conventional construction and maintenance practices specific to polyethylene can be readily transferable to PA1 1 piping systems. Based on these positive results, a waiver was successfully obtained from the Illinois Commerce Commission (ICC) and Department of Transportation (DOT) to install PAll piping systems in the public right of way at 150 psig. Both of these installations have not experienced any problems since they have been installed.

However, in order to gain additional practical operating experience, 5 additional installations have been planned. The objective of these installations is to further validate the safe operability of P11 piping systems operating at higher pressures in various climactic and geographic environments throughout the United States in order to support a rule change to the Code of Federal Regulations. This report provides a summary of the code requirements, PA11 piping system information, and pertinent data to support these proposed installations and the respective waiver requests.

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Chapter 1

1.1 Existing Code Requirements

Title 49, Part 192 of the Code of Federal Regulations governs the minimum requirements for the safe use of plastic piping systems. In particular, sections 192.121 and 192.123 prescribe procedures for determining the design pressure of thermoplastic pipe and its design limitations. Section 192.121, Design of Plastic Pipes, defines the formulation used for computing the design pressure. Section 192.123, Design Limitations of Plastic Pipe, limits the maximum pressure of plastic pipe to 100 psig. The sections are as follows:

§192.121 - Design for plastic pipe

The design pressure for plastic pipe is determined in accordance with the following formula, subject to the limitation of §192.123:

$$P = 2S\frac{t}{(D-t)}x0.32$$

[where] P = Design pressure, gage, kPa (psi)
S= For thermoplastic pipe the long-term hydrostatic strength determined in accordance with the listed specification at a temperature equal to 23°C (73°F), 38°C (100°F), 49°C (120°F), or 60°C (140°F); for reinforced thermosetting plastic pipe, 75,800 kPa (11,000 psi).
t = Specified wall thickness, mm (in.)
D= Specified outside diameter, mm (in.)
0.32= Design factor

§192.123 - Design limitations for plastic pipe

(a) The design pressure may not exceed a gauge pressure of 689 kPa (100 psig) for plastic pipe used in:
(1) Distribution systems; or
(2) Classes 3 and 4 locations.
(b) Plastic pipe may not be used where operating temperatures of the pipe will be: ...

1.2 **Proposed Changes to Code Requirements**

Based on the results of the comprehensive laboratory and field applications testing, the following changes are proposed to both sections 192.121 and 192.123, as shown below for each section respectively:

§192.121 - Design for plastic pipe

The design pressure for plastic pipe is determined in accordance with the following formula, subject to the limitation of § 192.123:

$$P = 2S\frac{t}{(D-t)}x0.40$$

[where] P = Design pressure, gage, kPa (psi)
S = For thermoplastic pipe the long-term hydrostatic strength determined in accordance with the listed specification at a temperature equal to 23°C (73°F), 38°C (100°F), 49°C (120°F), or 60°C (140°F); for reinforced thermosetting plastic pipe, 75,800 kPa (11,000 psi).
t = Specified wall thickness, mm (in.)

D = Specified outside diameter, mm (in.)
0.40= Design Factor

§192.123 - Design limitations for plastic pipe

(a) The design pressure may not exceed a gauge pressure of 689 kPa (100 psig) for plastic pipe used in:

(1) Distribution systems; or

(2) Classes 3 and 4 locations
Except as noted in Part 192.123(e)

(e) The design pressure may exceed a gauge pressure of 689 kPa (100 psig) as long as:

(1) the material shall be P11 as specified in ASTM D251396a

1.3 Explanation of the Proposed Revisions

1.3.1 Section 192.121

The principal proposed change in this section is the change in the design factor used in the equation for computing the design pressure for all thermoplastic piping installation from its current value of 0.32 to 0.40.

The basis for this proposal is the preference by a growing number of utilities to use more durable, corrosion resistant piping materials in gas distribution applications that are currently being serviced with steel pipe due to design pressure limitations. This measure would enable utilities to provide natural gas to customers in remote areas who are not presently being served due to higher piping/installation costs.

The American Gas Association (AGA) is finalizing its proposal to the Department of Transportation (DOT) which provides a comprehensive justification and rational basis for the proposed change as it relates to all thermoplastic piping material. Key points from this proposed draft include:

- Improved Raw Materials — Today's resins are much better with respect to performance under stress. Corresponding ASTM tests (elevated temperature stress rupture testing) have been found to be better predictors of long-term performance and there are well established validation procedures to confirm the long-term strength rating. In particular, through the use of these validated procedures, PA11 has successfully obtained a long-term HDB rating of 2500 psi.

- Basis of Design Factor — Originally, the design factor for PE pipe in gas applications in the U.S. was 0.40 with no problems attributed with this factor. The change adopted in 1978 was changed to 0.32 to coincide with the value being used for the other class locations. The single design factor 0.32 for all locations does not include any compensation for temperatures above 73°F.

- Related and Other International Standards — In the U.S., the accepted practice in the design of thermoplastic pipe for water application has been 0.50. The Canadian Standards Association (CSA) has also proposed changing the design factor to 0.40. The International Standards Organization (ISO) assigns design stresses of 580 psi and 725 psi to Medium Density (MDPE) and High Density (HDPE) polyethylene pipe. This is equivalent to applying design factors of 0.46 and 0.45 to MDPE and HDPE respectively.

- On-Going Studies — PA11 gas piping material has been studied extensively in both laboratory and field experiments to determine its integrity and any related safety issues. Example, Nicor under the auspices of the Gas Research Institute has complied data on PA11 characterizing all modes of failure which include short-term ductile failure and long-term slow crack growth failures. In addition, two separate installations of PA11 piping material operating at 150 psig has proven that the pipe material can withstand higher installation pressures. Conclusion — "the analysis of the data supports the use of PAU at service pressures up to 300 psig, and in conditions where to high temperatures [short-term, <24 hrs] would ordinarily preclude the use of plastic pipe [polyethylene].

1.3.2 Section 192.123

The principal proposed change in this section is to allow the design pressure for PA11 pipe to determined by its HDB rating-and not limited to 100 psig. This proposal is specific to PA11 pipe although similar proposals are currently being written for polyethylene.

Polyamide 11 (PA11) has a PPI Hydrostatic Design Basis of 2500 psi, which is a hydrostatic design stress of 800 psi (assuming a 0.32 design factor). PAl l has been successfully used for natural gas applications approximately 25 years at a design stress of 800 psi. The actual field applications for PA11 pipe has been SDR 33 (standard dimension ratio defined as the ratio of outside diameter to the wall thickness) pipes at a gauge pressure of 50 psig, which is equivalent to a stress of 800 psi. SDR 11 pipes operating at 160 psig and SDR 9 pipes operating at 200 psig would also have a stress of 800 psi. Consequently, this proposal would still have PAl l operating at a stress of 800 psi where it has a long successful history of operating at the corresponding pressures. The only change is that the design pressure limitation of 100 psig be eliminated hence the wall thickness is increased appropriately to achieve the desired pressure, as determined in accordance with Part § 192.121.

The American Gas Association (AGA) requested the AGA Plastic Materials Committee (AGA PMC) to determine if there is a broader interest throughout the gas industry. The AGA PMC committee held a workshop on March 2, 1995 to consider the use of plastic pipe above 100 psig. The major points of the workshop include:

- The utilities and gas industry manufacturers felt the 100 psig limit should be increased for new installations and there should be no numerical limit except that the design pressure should be determined by the design equation and the materials' inherent long-term properties

- Individual gas utilities petition their respective regulatory bodies to obtain waivers and gain experience and then approach the DOT

In addition to the industry wide support, there has been a successful previous precedent for the removal of the 100 psig limitation. The New York Department of Public Service on August 28, 1996 granted a waiver (Case 96-G-0213) to New York State Electric and Gas Corporation (NYSEG) of 16 NYCRR Section 255.123 of the Commissions Regulations permitting the use of HDPE up to 124 psig. Additionally, the Commission has also granted waivers to Central Hudson Gas & Electric Corporation and Long Island Lighting Company of the same requirement.

Also, the Canadian Standards have already removed the 100 psig limitation for plastic pipe. CSA-Z184-M92 states in Section 11.2.2.1 "the design pressure shall not exceed 700 kPa (100 psig). The current edition, modified in 1994, has deleted this limitation for plastic pipe. The design pressure is simply calculated using the standard Barlows formula contained within 192.121.

2.0 Polyamide 11 Piping Systems

2.1 What is P11?

Polyamide 11 is a thermoplastic belonging to the general class of polymers called polyamides. Polyamides are characterized by methylene groups of various lengths joined by amide linkages. The general formula for polyamides like Polyamide 11 is:

$$[NH\ (CH_2),\ CO]_n$$

Polyamide 11 was first commercially produced in 1955 by Organico in Serquigny, Normandy, France. Today, Polyamide 11 is produced by ATOFINA Chemicals (formerly Elf Atochem) in Serquigny, France and in Birdsboro, Pennsylvania. Polyamide 11 is available from ATOFINA Chemicals (ATO) under the trade name, Rilsan® B.

The characteristic unique to polyamides is the presence of amide groups. The basic difference between polyamide types is the frequency of occurrence of the amide groups in the polyamide chain. The lower number polyamides, i.e. polyamide 6, have the highest number of amide groups and, therefore the highest amide density.

Amide groups are polar. The polarity of the amide groups allow polyamides to exhibit interchain hydrogen bonding. The strength and degree of hydrogen bonding gives polyamides their strength and toughness. The polarity of the amide groups and the amide density also account for the moisture absorption characteristics of polyamides. Polyamides absorb moisture reversibly. The amount of moisture absorbed is dependent on the amide density. Polyamides with high amide concentration (PA6) absorb greater amounts of moisture than low amide density polyamides (PA11). For polyamides like Polyamide 11 this results in greater dimensional stability and less of a change in physical properties when compared to high amide density polyamides like Polyamide 6.

At present, PA11 resin is produced and sold to the CSR Polypipe (CSR) who is the commercial pipe manufacturer. CSR, a business unit of CSR Pipelines Systems, offers a complete range of PE piping systems to the United States natural gas industry. CSR is one of the nations largest manufactures of pressure rated PE pipe, PE valves, and fabricated fittings. Like PE piping systems, PA11 piping system posses all the necessary industry specifications which allow its use in natural gas distribution systems. PA11 has an approved ASTM classification and is listed with ASTM D2513 specification under Annex A5. Furthermore, PA11 has an established Plastic Pipe Institute-(PPI) Hydrostatic Design Basis (HDB) rating. At 73°F (23°C) PA11 has an HDB rating of 2500 psi, which is twice that of MDPE materials. At elevated temperatures, 176°F (80°C), PA11 has an HDB rating of 1250 psi.

2.2 Comparison to PE

As previously mentioned, the presence of the amide groups is unique to polyamides. If the amide groups were omitted from the polymer chain, the resulting polymer would be a long chain aliphatic hydrocarbon similar to polyethylene. These amide groups also make PA11 a polar material. In contrast, polyethylene are non-polar materials. Consequently, these materials cannot be joined, i.e. one cannot by mistake heat fuse PAl I to PE.

Beyond the molecular level, there are additional differences with respect to material and physical properties and long term strength which enables its use at increased operating pressures, as shown in Table 1.

PROPERTY	METHOD	PA11	HDPE	MDPE
Density (kg/m^3)		1030	950	940
Melting point		183-187°C	128- 132°C	124-128°C
Vicat softening point at 10N	ISO 306	180°C	124°C	120°C
Tensile stress at yield (MPa)	ISO R527	42	24	18
Elongation at yield	ISO R527	8%	16%	13%
Tensile stress at break (MPa)	ISO R527	53	35	27
Elongation at break	ISO R527	300%	> 800%	> 800%
Modulus of elasticity in flexure (MPa)	ISO 178	1000	950	700
Impact strength, Charpy (kj/m^2)	ISO 179	No break	no break	no break
Hardness, Rockwell Shore D	ISO 2039/2	108	82	42
Linear thermal expansion	ISO 868 0°C-100°C (10-6/k)	85 150	63 190	58 240
Water absorption, 24h immersion		0.3%	< 0.1%	< 0.1%
Equilibrium water absorption 50% RH 100% RH	 0.9% 1.9%	 <0.1%	 <0.1%	
Pipe Properties:				
One hour hoop strength (MPa)		33	15	13
Fifty year hoop strength (MPa)		15	6.5	8
Relative weight per unit length		0.4	1.0	1.0
Perform squeeze-off operation		yes	yes	yes

Table 1: Comparison of the typical properties of plastic gas pipe materials

Table 2 demonstrates a comparison of certain key operational related characteristics of both medium density PE and Polyamide 11 materials. It is evident that PA11 has all of the advantages as MDPE; in addition, PAll has increased hydrostatic design basis, increased temperature resistance, increased chemical resistance in particular hydrocarbons.

Characteristics	MDPE	PA11
HDB @ 73°F	1250 psi	2500 psi
MAOP for SDR11 Design factor = 0.32	80 psig	160 psi

MAOP for SDR 9 Design factor = 0.32	100 psig	200 psi
Comments:	Light weight	Light weight
	Available in coils	Available in coils
	Very good resistance to SCG	Very good resistance to SCG
	Easy to join (Butt fusion)	Easy to join (Butt fusion)
	Will retain 140°F HDB rating	Will retain 140°F HDB rating
	Corrosion resistant	Will retain 180°F HDB rating
		Corrosion resistant
		Resistant to hydrocarbons

TABLE 2: Comparison of key operating characteristics of plastic gas pipe materials

2.3 Laboratory Testing and Evaluation

Before any new plastic material can be deemed acceptable for use by LDC's, it must be subjected to a comprehensive range of testing and evaluation to firmly establish that it is not inferior to current materials in terms of strength, fracture resistance, and long-term durability, and that it can be safely and economically used in the natural gas industry's installation and maintenance procedures. Therefore, the comprehensive research program was undertaken to critically examine the performance of Pa11 pipe for use at higher operating pressures.

To accomplish the project objectives an integrated experimental and analytical program was conducted. It is generally recognized that there are three common modes of failure for plastic gas distribution pipes: short-term ductile rupture, long-term slow crack growth (SCG), and rapid crack propagation (RCP). Currently, there are approximately sixty various ASTM test methods that address the physical, mechanical, and chemical properties of plastic pipe. Until recently, SCG and RCP testing were not covered. Tests and analysis procedures that address these areas were established in the US through GTI sponsored research and are now contained within ASTM standards and specifications. The cumulative results of each of these tests help in the characterizing the structural integrity of the pipe in terms of its ability to withstand the stresses caused by internal gas pressure and to prevent leakage through the pipe wall and joints.

Three individual lots of 2 inch IPS SDR 11 pipe were produced from three distinct lots of PA11 resin. Comprehensive testing and evaluation was performed per ASTM D2513 specifications and its respective referenced test methods. Additional tests such as three-point bend sector test and S4 testing were also performed to address the long term resistance to slow crack growth and the RCP resistance of PA11, respectively.

The results of the comprehensive testing and evaluation demonstrated that PA11 pipe can safely be operated at higher pressures. The results of the comprehensive testing has been summarized in a GTI report entitled "Technical Reference on the Physical, Mechanical, and Chemical Properties of PA11 Pipe Materials for Use in Gas Distribution Piping Systems Operating at Higher Pressures and Temperatures" (GTI Report # 99/0039).

In order to realize the complete benefits of PA11 materials, it was imperative to develop an entire system made from PA11 that can operate at higher pressures. The system must not only consist of P11 pipe material but also components such as valves, tees, and other necessary fittings.

Several specimens for various fittings were subjected to comprehensive testing and evaluation in laboratory conditions per prescribed ASTM and ANSI standards and their respective referenced test methods. The results of the testing demonstrated that both PA11 pipe and components made from PA11 including mechanical fittings, valves, molded fusion fittings, transition fittings, etc were capable of operating at higher pressures. The results are summarized in a GTI report entitled "Evaluation of P11 Piping for Use in Gas Distribution Piping Systems Operating at High Pressures and Temperatures" (GTI Report # 00/0050).

2.4 1997 Pilot Installation

Given the positive results of the laboratory testing and evaluation of the PA11 system consisting of pipe and appurtenances, a trial installation was planned on Nicor Gas' private property after the meter set. The objectives of this trial installation were to evaluate the storage and handling capabilities of PA11 pipe, the effect of various installation techniques, and the impact on various operating procedures with the use of PA11 piping materials. In particular, the trial installation was carried out to determine whether or not conventional operating practices specific to polyethylene could be utilized with PA11 piping systems.

Figure 1 illustrates the 1997 Nicor Gas Pilot installation (see original

Figure 1: 150 psig trial installation schematic on Nicor Gas property (see original)

Approximately 400 feet of 2 inch SDR11 pipe in 10 foot stick pieces of pipe were heat fused using fusion procedures specific to P11 . A 150 psig feeder main servicing other parts of the Nicor Gas infrastructure was used as the feeder line for the test loop. Approximately 25 feet of 2 inch steel piping was extended from the inlet of the first stage to serve as the supply line. A 2 inch steel to PA11 transition fitting was welded to the end of the steel pipe section.

A Vermeer FlexTrak 115 planting/plowing machine was used to install approximately 50 feet of 2 inch PA11 pipe. Approximately 250 feet of PA11 pipe was installed using the directional boring technique. An inverted transition fitting was heat fused outdoors to one end of the PA11 pipe, which served as a pulling head for the pipe section. The remaining 200 feet of pipe was heat fused to the end of the directionally bored pipe section. A open cut trench was made with a 30 feet bend radius.

Once the entire pipe length was installed, an elbow (90°) fitting was heat fused to both the end sections of the planted and directionally bored segments. Another transition fitting was installed at the end section of the entire pipe length. The transition fitting was modified to include a valve and a nipple to serve as end connections for purging and pressure testing. The entire test loop was then pressure tested at 230 psig, which is 1.5 times the design pressure. The pressure test was carried out for 1 hour. All of the exposed joints were tested for leaks and the pressure was monitored with the use of a chart gauge throughout the test.

The line was then purged with Air/Nitrogen mixture followed by natural gas. The PA1 I pipe was wetted down with anti-static fluid. A mechanical tee was installed according to the manufacturers specifications. The seals were tested for the presence of leaks. With the use of a 2 inch pressure test tool provided by the manufacturer, the mechanical fitting was pressure tested for 1 hour at 230 psig. After the pressure testing, the tee was tapped against a line pressure of 150 psig using the manufacturers' guidelines and capped.

All of the remaining ditches and trench were back filled and pipeline markers were installed over the PAU piping system. Periodic leak inspections were carried out to determine the presence of any leaks at the joints. The installed PAll pipe has been in service since October 1997 without any problems or leaks.

The results of the trial installation have been documented on video and are available through GT1.

2.5 ICC Waiver and 1999 Public Right of Way Installation

Based on the positive performance of the PATH in both laboratory and field application environments, a final field installation was planned and executed in the public right of way.

Because the intended operating pressure was greater than currently allowed for by 49CFR Part 192.121 and

192.123, a waiver was filed and accepted by both the state (Illinois Commerce Commission) and federal regulatory bodies (Department of Transportation Office of Pipeline Safety). The waiver allowed the use of PA11 piping systems to operate at pressures as limited by its HDB rating and the use of the design formula contained within Part 192.121 with the following conditions.

- Must follow all code requirements pertaining to plastics, e.g. joining and pressure testing
- Increase signage and additional leak inspections
- Must backfill with sand to indicate the presence of PA11
- Must "cold" tap all mechanical fittings for service lines (depressurized pipes)
- Must acquire aging characteristics after 12 months and 24 months of exposure to in-service conditions

The public right of way installation was initiated and completed in December 1999 with an average ambient temperature ranging between 25°F to 45°F and less than ideal conditions (periodic rain and snow). The installation, as shown in Figure 2, is a single feed system consisting of 5300 feet of 2-inch IPS PA11 pipe for the main. A regulator unit set to 150 psig- serves the system. There are six service lines consisting of three major components: 1-inch IPS PA11 pipe running from the 2x1 inch service tee on the main to the inlet of the first stage regulator; a first-stage regulator which reduces the delivery pressure from 150 psig to approximately 40 psig; and 1/2-inch MDPE pipe running from the outlet of the first stage regulator to the meter set at the house. In order to facilitate the removal of pipe sections for further aging characterization, 2-inch PA11 valves were strategically placed downstream of the last service.

Figure 2 Illustration of the 150 psig public right of way field installation (see original)

The installation has been in-service since December of 1999 and has not experienced any problems. The most significant conclusion of the installation was that conventional operating practices specific to PE are readily transferable to PA1 1 piping systems. A comprehensive summary of the waiver request, installation planning, and construction details is provided in a GTI report entitled "Field Installation and Aging Characteristic Evaluation of PA11 Piping for Use in Gas Distribution Systems Operating at High Pressures and Temperatures" (GTI Report # 00/107).

2.6 Aging Characteristics

An important criterion imposed by the Illinois Commerce Commission was to examine the aging characteristics of PAll piping systems at periodic time intervals, specifically 12 and 24 months. In order to take a proactive stance, sample length of pipe specimens were removed from the 1997 pilot installation (see section 2.4) at 18 and 30 month time intervals.

In previous GTI sponsored research, it was shown that PE materials exhibit no change with respect to material properties under exposure to in-service conditions. Sections of PA11pipe were removed and subjected to identical testmethodology used in the previous GTI research. The tests consisted of several short term and long term strength determinations.

The results of the testing demonstrated that there is a small scale decrease with the material properties of PAl 1 pipe; however, the material properties still exceed the allowable limits per ASTM D2513 by a factor 150%, as shown in Figure 3. (see original

Figure 3 Comparison of the physical properties after exposure to in-service conditions as a function of time

Figure 3 shows the results of the hydrostatic quick burst testing and tensile strength testing as a function of time. It is evident that there is a 10-15% decrease in the short term properties of the PA11 material at 18 months. This decrease is a result of the moisture absorption characteristics of PA11. However, the decrease reaches an asymptotic limit as a function of the equilibrium moisture absorption content of PA1 1. This is

evident from the fact that at 30 months, there is no additional decrease in the material strength as compared to 18 months. Furthermore, after 30 months of exposure to in-service conditions, the material properties are approximately 150% greater than those specified in ASTM D2513 Annex A5, indicated by the straight line at 3900 psi in Figure 3.

A comprehensive summary of the aging characterization studies can be found in GRI report entitled "Field Installation and Aging Characteristic Evaluation of PA11 Piping for Use in Gas Distribution Systems Operating at High Pressures and Temperatures" (GTI Report # 00/107).

3.0 Summary and Conclusions

The US natural gas industry has understood the benefits of using plastic gas piping systems. In addition to being easier to handle and join, the use of plastic piping materials provides tremendous economic advantages by reducing long term corrosion control and overall total installed costs. Nevertheless, given the current ratings for medium density (MD) and high density (HD) polyethylene (PE) piping materials, operations at substantially higher pressures than are currently being used are not possible. There has been a tremendous need to identify and evaluate new plastic materials that can operate at higher operating pressures (150 — 300 psig) while providing savings with respect to overall installed costs. One promising new technology is Polyarnide 11 (PA11).

PA11 has been used extensively abroad within the natural gas distribution systems in Australia. PA11 has met all industry standards and approvals for use in the US natural gas industry. It has been annexed within ASTM D2513 and has an approved PPI HDB rating. Furthermore, PA11 fittings have been used in the United States safely and reliably for the past 6 years in low pressure systems (60 psig).

Given its increased HDB ratings, as compared to PE piping materials, a comprehensive testing and evaluation program was carried out under the sponsorship of the Gas Technology Institute, leading utilities, and key gas industry manufacturing companies. The objective of the program to validate the use of the PA11 piping systems in order to provide local distribution companies a safe and reliable alternative to steel at higher operating pressures. Through a series of comprehensive short term and testing and field applications testing, the following conclusions were made:

- PA11 pipe and fitting materials either met and/or exceeded the requirements contained in all applicable ASTM and industry standards and specifications
- Field evaluations of PA11 piping demonstrated that conventional construction and maintenance operating practices specific to PE can be readily transferred to PA11 piping systems. Given the differences in the material properties of PA11, a slightly higher heater iron temperature is required for heat fusions.
- Two separate installations were planned and executed at 150 psig operating pressure. Both installations have not experienced any problems. The first installation of the two has been in-service since October 1997.
- Aging characterization studies to characterize the effects of in-service conditions have shown that the PA11 material properties still exceed the limits of ASTM D2513 by 150% after 30 months of exposure. Furthermore, the results of the long term testing demonstrate that PAU retains its long term strength and resistance to slow crack growth.

The cumulative results of the laboratory testing and field applications testing have successfully validated the use of PA11 piping systems at higher operating pressures. However, additional installations have been planned to characterize the effects of different climactic and geographic conditions on PA11 piping systems, which will provide a sufficient database to petition the DOT for a rule change.